

**ANNUAL REPORT
Calendar Year 2012**

NRSP-6: UNITED STATES POTATO GENE BANK

Acquisition, Classification, Preservation, Evaluation and Distribution of tuber-bearing *Solanum* Species.

COOPERATIVE AGENCIES AND PRINCIPAL LEADERS

State Agricultural Experimental Stations

Representative

Technical Representatives

Southern Region		C. Yencho
Western Region	Chair (2013)	D. Holm
North Central Region	Vice Chair (2013)	D. Douches
Northeastern Region		W. De Jong

Administrative Advisors

Southern Region		C. Nessler
Western Region		L. Curtis
North Central Region	Lead AA	R. Lindroth
Northeastern Region		E. Ashworth

United States Department of Agriculture

ARS

Technical Representative	Secretary (2013)	C. Brown
National Program Staff		P. Bretting
		G. Wisler
Midwest Area		R. Matteri & P. Simon

NIFA

A. M. Thro

APHIS

J. Abad

NRSP-6 Project Leader

J. Bamberg

Agriculture & Agrifood Canada

B. Bizimungu

PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. Acquisitions and associated work

In 2012, the collecting and research activities in the southwest USA passed the 20-year milestone, and represented our most ambitious trip thus far. We accomplished each of six objectives: 1) Venue scouting for Hungry Film Inc., 2) Re-discover *fendleri* at Demlong 119 at Riggs Lake (Pinaleno Mts.) diversity hotspot, 3) *Matryoshka* fruit mutant re-collections 4) Fruit gall collecting 5) Patagonia and Canelo Mountains exploration (20 new germplasm accessions), 6) 20th anniversary reunion collecting and Hungry Film Inc. documentary shooting. USDA/ARS/Plant Exploration Office supplied \$5K. A detailed trip report is available on request.



Hungry Film at Rincons trailhead by Tanque Verde Ranch (L-R: del Rio, Gallup, Johnson, McLeod, Bamberg)



We imported 11 elite breeding stocks from other countries. We conducted an expedition to Arizona to collect 20 wild populations (B4dRFS).



Jana Suriano makes Demlong 119 re-discovery

The NRSP-6 web page (<http://www.ars-grin.gov/nr6>) was updated to include all new stocks and screening information. Clients who have ordered from NRSP-6 within the past four years were contacted three times in 2012, informing them of new stocks of true seed, tubers, in vitro plantlets, or herbarium samples. We used email and the website to extend technical instruction like transplanting techniques and use of nylon slipper socks for preparing samples.

B. Preservation and Evaluation

A total of 203 accessions were increased as botanical seed populations and 1818 clonally. About 1010 potato virus tests were performed on seed increase parents, seedlots and research materials. Germination tests were performed on 1131 accessions, ploidy determinations were made on 28 accessions, and tetrazolium seed viability tests were done on 26 seedlots.

With help of cooperators, we made progress evaluating and improving germplasm on several ongoing projects. Over 2200 field plots at USPG, about 500 field plots in two sites in CA, and 4 large screenhouses at USPG full of stocks supporting screening for golden tuber flesh, antioxidants, folate, thiamine, tomatine, anti-obesity, forms in series LON, starch balance, % dry matter, anti-diabetes, allergenicity, tuber greening, K-reduction, *Matryoshka* fruit mutant, GA dwarfism, sessile tubers, taste, and floral volatiles.

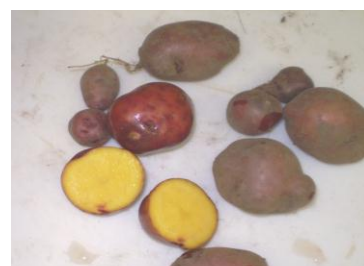


Another excellent seed increase year



New *Matryoshka* floral mutant

This year, the project to select orange-fleshed stocks from hybrids of *S. phureja* based on taste, appearance and cooking quality evaluated by a native Colombian (FL) familiar with the ideal for traditional *papa criolla* resulted in the first selections declared good enough for market by cooperator. With A. Goyer (OR), we screened all *microdontum* populations for tomatate, produced materials for fine screening and MAS breeding. Lack of folate is associated with a broad range of serious physical and mental diseases.

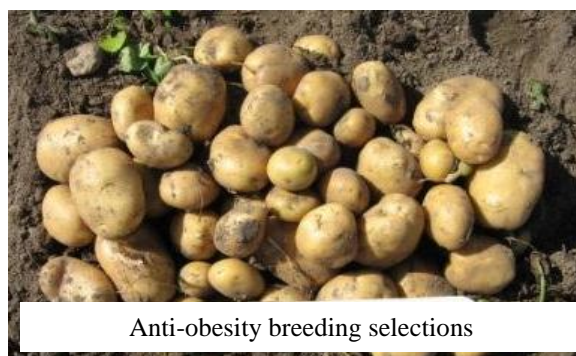


Orange flesh *papa criolla* type



The cooperative project with Kemin (IA) continued to make gains in 2012. Exotics were identified and hybridized that have over 6-fold the concentration of an anti-appetite compound of common cultivars. We selected some with very high levels and good tuber type. This addresses the US obesity epidemic, which is responsible for more than 1/5 of all healthcare-related costs. We expanded work on the *Microdontum* Multifaceted Project

(MMP) by identifying 1741 informative AFLP loci for help in selecting a core collection. AFLP loci were treated as though they were traits, with the banded condition considered to be the desired state. At least one band unique to a population was present in 45 populations, and these 45 populations together captured 98% of all bands. Adding another 14 populations for a total of 59 captured all bands. This core set was assessed for whether it encompassed those



Anti-obesity breeding selections

populations known to have useful traits, including nutritional and quality components, as well as disease, stress and pest resistances. As with AFLP bands, all 25 of the most desirable phenotypic traits were also found in populations in the core set of 59 populations. These AFLP markers may also reveal the influence of eco-geo parameters, and introgression from other species. In hybrids of this same species, we confirmed extreme tuber greening resistance after illumination exhibits high heritability.

Short day winter growouts in three places in California continue to be used to extend our evaluation capacity.

This year, work with cooperators J. Palta (UW), International Potato Center, and the Peruvian national potato program resulted in selections from our cold hardiness breeding project with *S. commersonii* that were declared by local Puno farmers to be hardy and productive enough to be cultivars.



Solanum microdontum



Tuber greening results in significant economic loss

Success of NRSP6 frost hardy hybrids in Peruvian highlands



It is hard to overestimate the importance of diabetes when one considers the recent rapid increase in diagnoses worldwide, the chronic nature of the disease, and how it exacerbates other major diseases of the kidneys, cardiovascular and nervous systems, and attendant amputations, and blindness. The ADA estimates diabetes at about 26m persons in the USA, and another 80m with prediabetes, for total annual healthcare costs at \$174B. This year it was reported that potato cultivars contain significant levels of biguanides, the antigluconogenic compounds in Metformin. We have already produced and sent tubers of 25 representative wild species' tubers to cooperators at CSU in hopes of finding germplasm with high biguanide levels.



Coming soon... a potato that reduces occurrence and impact of diabetes?

C. Classification

David Spooner's work related to NRSP6 this year included: 1) the use of plastid microsatellites to investigate cultivated potato diversity and origins, 2) a summary of the use of next-generation sequencing techniques for plants, 3) a genomics in-situ hybridization (GISH) analysis of polyploidy in North and Central American hexaploid potato species, 4) an analysis of resistance to potato wart disease (*Synchytrium endobioticum*) in cultivated potatoes, 5) a treatment of potato in an upcoming encyclopedia of genetics.



Taxonomic implication in potato wart disease

D. Distribution service



Distribution of germplasm is at the heart of our service. The volume and types of stocks sent to various consignee categories are summarized in the table below. **Total orders increased about 20% in 2012.** NRSP-6 distributed **190** domestic orders to clients in 23 states of the USA and **22** foreign orders to **12** other countries. About ½ of domestic orders are for breeding and genetics, about ¼ for home gardeners, and the remaining ¼ for pathology, physiology, entomology, taxonomy, and education. In 2012 we maintained the popular offering of 100 cultivars as tubers by devising and implementing an iron-clad disease control and quarantine program for their production (full details available at our website).

Category	Units of Germplasm Sent ¹							Total	PIs
	Seed	TU	TC	IV	DNA	Plants	Herb		
Domestic	2,069	3	3,210	1,692	6	73	0	7,053	4,981
Foreign	1,088	0	0	318	0	0	0	1,406	1,194
Total	3,157	3	3,210	2,010	6	73	0	8,459	6,175

¹ Types of stocks sent/(number of seeds, tubers or plantlets per standard shipping unit): Seed= True Seeds/(50), TU = Tuber families/(12), TC = Tuber Clones/(3), IV = *in vitro* stocks/(3), DNA = dried leaf samples/(1), Plants = rooted cuttings /(1), Herb= herbarium specimens/(1).

E. Outreach

Media coverage, Tours, Teaching, TechTran and Trips with presentations done

Milwaukee Journal Sentinel syndicated article on genebank

Wisconsin Public Television filming for *Wisconsin Gardener* show

Hungry Film Inc. of NY films our potato collecting for three days in Arizona

UW CALS dean K. VandenBosch visit

Southern Door HS student mock interview as English class exercise

Summer student interns participated in experiments: Kyle LaPlante (UW Madison): antioxidant and folate enhancement, grafting. Jana Suriano (Princeton): K-reduction, *Matryoshka* mutant genetics, tuber greening, germination enhancement with activated charcoal.

J.R. Simplot Co. geneticist Michele Krucker visits, proposes high protein screening.

Cornell postdocs S. Campbell and R. Halitschke visit to collect volatiles from jasmonate-treated flowers

Kemin Industry geneticist Brindha Narasimhamoorthy and Matt Parks visit and help field harvest

Curzio Caravati of *SeedSavers* Kenosha visits and engages taste evaluation cooperation

Methodist Men's Group of Sturgeon Bay given ppt presentation on genebank

Southern Door HS Spanish class given ppt presentation on genebank *in Spanish*

NCR potato genetics group meeting in Chicago presentation
Potato Association of America meeting in Denver-- four research presentations/abstracts
Santa Rita mountains (AZ) re-collection of *Matryoshka* floral mutant with student Jana Suriano
Chinese scientists (8) visit with host J. Palta
Bamberg served as PhD committee member for Cinthya Zorrilla-C
Tour and presentation to Lost Lake Garden Association

Leadership: Bamberg continued as Editor in Chief for the American Journal of Potato Research, and Chair of the USDA/ARS Potato Crop Germplasm Committee.

Reports & Plans: ARS: PGO, CGC, OSQR, CRIS, Annual Performance, Budget. NRSP6: Annual Report, Budget proposal, TAC meeting minutes. PAA: AJPR Editor in Chief report, support letter for Honorary Life Member and introduction at Awards Banquet. UW-Hort: 10-year review and 5-year faculty review, Annual Performance. PARS: Tour guide & field book.

Management of Grants & Awards: Potato CGC grants, AJPR Outstanding Paper, retiring AJPR senior editors and NRSP6 technical reps

Scholarly Publications: See below.

IMPACT STATEMENT

In 2012, seed increases were very successful (over 200) and orders for germplasm increased over 20%. We uploaded much evaluation data on percent dry matter and unique AFLP alleles to the public internet database.

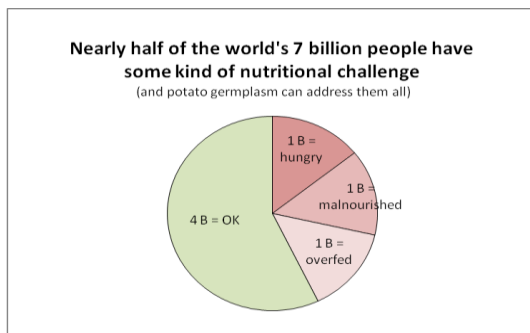
The payoff in funding the genebank is in discovering and deploying traits that are useful to the public and the industry. We participated in successful selection of better stocks for golden flesh, desired yellow fry color, very high levels of total antioxidants, frost resistance in Peruvian highlands, anti-diabetes compounds, folate, potassium, resistance to tuber greening, and a natural appetite suppressing protein,.

We continued work on improving germplasm management. We again collected germplasm in-country, finding populations at sites never before reported or collected.

We developed tech transfer like use of cheap nylon slipper socks for sample drying bags.

Salary and travel support plus cash gifts from industry totaled \$48K in 2012.

Cheap nylon slipper socks make great tuber sample drying containers



Of the 7 billion people on earth, one billion lack enough calories, one billion have enough calories, but are hurting for lack of essential nutrients, and another billion are overfed (The Economist, Feb18, 2012). NRSP6 works with collaborators to impact each of these one-billion-man problems.

Stroke, cancer and obesity costs in the US are at least 100 times that of the total annual farmgate value of the potato crop, so we conclude that the prospect of making a significant impact

through nutrition compares favorably with using germplasm to increase yield or reduce production costs.

However, a more nutritious potato may also be the best help for producers, if a better potato would increase demand and its competitiveness with other food alternatives.

The genebank's role is two-fold—providing the germplasm and also providing the ideas and technology for how it can be best deployed.

The genebank assists germplasm users by providing custom samples and technology.

We have generated adapted selections for... extremely high antioxidants, anti-appetite protein, orange flesh, frost resistance. Raw germplasm has been identified with extremely high folate, total protein, calcium use efficiency. We are planning or started on anti-diabetes biguanides, potassium, salicylic acid, anti-cancer tomatine, low allergenicity.

Genebank evaluation role:
Helping cooperators by designing & creating custom materials

- ✓ Representative pops within a core set of species
- ✓ Bulk pops within elite species
- ✓ Fine (genotype-level) screen within elite pops
- ✓ Discovery or synthesis of pops with highest, pure expression of trait
- ✓ Make wide F₂ for genetics, physiology, associated marker identification
- ✓ Cross into adapted background (pre-breed)



Releases of potato varieties and germplasm in 2012 and NRSP-6 exotic species in their pedigrees

No other crop can compare to potato in utilization of exotic germplasm:

M7 Germplasm Release: Expanding the germplasm base for French Fry processing, *S. infundibuliforme*

AmaRosa: A red skinned, red fleshed fingerling with high phytonutrient value, *S. demissum*

Purple Pelisse: A fingerling potato with purple skin and flesh, *S. vernei*

Owyhee Russet: A high yielding variety with excellent processing quality and resistance to dry rot, *S. chacoense*

Palisade Russet: A late blight resistant variety with low incidence of sugar end and high specific gravity, *S. andigena*

Saikai 35: Germplasm release carrying resistance to Potato Cyst Nematode and Potato Virus Y, *S. phureja*

The ability to efficiently evaluate traits is rapidly improving. We are on the brink of a leap forward in breeding through molecular markers and genetic technology. Potato is an increasingly important world food. Climate is changing, and health issues and their economic impact are increasing in our aging population. Because of these factors, there has never been a more important (or exciting) time to be involved in improving potato through mining the rich deposits of traits in the US Potato Genebank.

WORK PLANS / STAFF & FUNDING / ADMINISTRATION

Reduction in USDA/ARS funding in FY12 that resulted in losing ½ of a position (del Rio) will require limiting our activities to the highest priority genetic diversity management studies. We expect to continue to pinch labor pennies with inexpensive summer student interns and volunteers. Travel spending is expected to again be very conservative and significantly paid by outside sponsors. As reported last year, the upcoming year will require increased efforts to deploy equipment, facilities, and skills in the most efficient way. One strategy that has proved effective will be continued: Finding multiple uses, or gathering multiple types of data from each grow-out. We expect to spend the considerable time and effort needed to pursue the continuation of required industry contributions we received in 2012.

PUBLICATIONS

NRSP6 and associated USDA/ARS project staff publications

Bamberg, JB and JC Miller, Jr. Comparisons of gal1 with other reputed gibberellin mutants in potato. American Journal of Potato Research 89:142-149.

Cai, D, F Rodriguez, Y Teng, C Ane, M Bonierbale, LA Mueller, and DM Spooner. Single copy nuclear gene analysis of polyploidy in wild potatoes (*Solanum* section Petota). BMC Evolutionary Biology 12:

del Rio, Alfonso H., JB Bamberg, Ruth Centeno Diaz, J. Soto, A. Salas, W. Roca and D. Tay. Pesticide contamination has little effect on the genetic diversity of potato species. American Journal of Potato Research 89:348-391.

del Rio, Alfonso H., JB Bamberg, Ruth Centeno-Diaz, A. Salas, W. Roca and D. Tay. Effects of the pesticide Furadan on traits associated with reproduction of wild potato species. American Journal of Plant Sciences 3:1608-1612.

Egan, A.N., Schlueter, J., Spooner, D.M. Applications of next-generation sequencing in plant biology. American Journal of Botany 99:175-185.

Goyer, A., C Brown, R Knowles, L Knowles and JB Bamberg. Attacking the acrylamide dilemma by developing low sugar high carotenoid processing potatoes. Potato Progress (Washington State Potato Commission): 12(1):2-3.

Haga, E., Weber, B., Jansky, S. Examination of potential measures of vine maturity in potato. American Journal of Plant Sciences 3:495-505.

Jansky, S., Hamernik, A., Cai, X. Rapid cycling with true potato seed. Seed Science and Technology 40:43-50.

Khiutti, A., Afanasenko, O., Antonova, O., Shuvalov, O., Novikova, L., Krylova, E., Chalaya, N., Mironenko, N., Spooner, D.M., Gavrilenko, T. Characterization of resistance to *Synchytrium endobioticum* in cultivated potato accessions from the collection of Vavilov Institute of Plant Industry. Plant Breeding 131:744-750.

Kittipadukal, P., Bethke, P.C., Jansky, S.H. The effect of photoperiod on tuberisation in cultivated and wild potato species hybrids. Potato Research 55:27-40.

Pendinen, G., Spooner, D.M., Jiang, J., Gavrilenko, T. Genomic in situ hybridization reveals both auto- and allopolyploid origins of different North and Central American hexaploid potato (*Solanum* sect. Petota) species. Genome 55:407-415.

Spooner, D., Jansky, S., Clausen, A., del Rosario Herrera, M., Ghislain, M. The Enigma of *Solanum maglia*. In: the Origin of the Chilean Cultivated Potato, *Solanum tuberosum* Chilotanum Group(1). Economic Botany 66:12-21.

Weber, B.N., Hamernik, A.J., Jansky, S.H. Hybridization barriers between diploid *Solanum tuberosum* and wild *Solanum raphanifolium*. Genetic Resources and Crop Evolution 59:1287-1293.

Weber, B.N., Jansky, S.H. Resistance to *Alternaria solani* in hybrids between a *Solanum tuberosum* haploid and *S. raphanifolium*. Phytopathology 102:214-221.

Publications by others using NRSP6 stocks

Many other scientists are publishing research that directly or indirectly originated from NRSP6 stocks. Publications that mention potato species (both old and new taxonomy) are likely to have such a connection to USPG germplasm and service. The search below produced 140 hits which the reader can regenerate independently, or which can be accessed through our website: <http://www.ars-grin.gov/nr6>.

The search net below does not catch cultivars, breeding stocks and genetic stocks, which have some 900 particular names to search, or are *tuberosum* and therefore more likely to be of independent origin. Note that even when the publication is of foreign origin, and the researcher probably received materials from another genebank, that foreign genebank may have originally received those materials from USPG. Since potato research and breeding is a slow process, materials published in 2012 could, of course, have been ordered many years previously. Similarly, these articles may only cite previous work with exotic species as related background information published by others, not because they were the materials used in the present experiment.

Digitop > browse by type: Databases > AGRICOLA > (log in) > cut and paste string below into "simple search" box > click "go"

This hits 140 records in Agricola or CAB abstracts for 2012 -- 123 for 2010 and 129 for 2011

Solanum and (abancayense or acaule or achacachense or acroglossum or acroscopicum or aemulans or agrimonifolium or ajanhuiri or alandiae or albicans or albornozii or ambosinum or andreanum or arnezii or astleyi or avilesii or aymaraesense or berthaultii or blanco-galdosii or boliviense or brachistotrichum or brachycarpum or brevicaule or buesii or bukasovii or bulbocastanum or burkartii or cajamarquense or canasense or candolleum or capsicibaccatum or cardiophyllum or chacoense or chancayense or chilliasense or chillonanum or chiquidenum or chomatophilum or circaeifolium or clarum or coelestipetalum or colombianum or commersonii or contumazaense or curtilobum or demissum or doddsii or dolichocremastrum or edinense or edinense or ehrenbergii or etuberosum or fendleri or fernandezianum or flahaultii or gandarillasii or garcia-barrigae or gourlayi or guerreroense or hintonii or hjertingii or hondelmannii or hoopesii or hougassii or huancabambense or hypacrarthrum or immite or incamayoense or infundibuliforme or iopetalum or irosinum or jamesii or juzepczukii or kurtzianum or laxissimum or leptophyes or leptosepalum or lesteri or lignicaule or limbaniense or lobbianum or longiconicum or macropilosum or maglia or malmeanum or marinasense or matehualae or medians or megistacrobium or michoacanum or microdontum or minutifoliolum or mochiquense or morelliforme or moscopanum or multidissectum or multiinterruptum or nayaritense or neocardenasii or neorossii or neovalenzuelae or okadae or oplocense or orocense or orophilum or otites or oxycarpum or palustre or pampasense or papita or paramoense or pascoense or paucijugum or paucissectum or phureja or pinnatisectum or piurae or polyadenium or polytrichon or raphanifolium or rechei or sambucinum or sanctae-rosae or sandemanii or santolallae or scabrifolium or schenckii or soestii or sogarandinum or solisii or sparsipilum or spegazzinii or stenophyllidium or stoloniferum or subpanduratum or sucense or sucubunense or tarijense or tarnii or trifidum or tundalomense or tuquerrense or ugentii or velardei or venturii or vernei or verrucosum or violaceimarmoratum or weberbaueri or yungasense or goniocalyx or stenotomum or andigenum or andigena or (USDA and "Solanum tuberosum")) (doc-type:Articles or doc-type:Books) pub-year:2012